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GEORGE R. BROWN CONVENTION CENTER

Export Gas Compressors Vorecon vibration Analysis

Presented by:

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TEXAS A&M ENGINEERING EXPERIMENT STATION

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- Chandra Sivapuram P.E – Shell Canada.
- Presently working on assignment with Motiva Enterprise – Port Arthur Refinery, as Senior Rotating Equipment Engineer.
- After graduation in Mechanical Engineering, worked in Indian off-shore / on-shore projects, Middle East, Canada in Heavy Oil, and North Caspian on-shore processing facilities.
- 25+ years experience in Upstream / Mid-stream / Down Stream & Oil Sands – Heavy Oil Machinery Engineering & Project support

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Agenda

- Problem statement
- Historical background
- Inspection of unit KC011
- Vibration data analysis from site
- Coupling design check
- Preliminary considerations
- Next steps

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- **Probleme statement**
- **During commissioning , several Sales Gas Compressor units impacted by subsyncronous vibrations**
- **Vibrations occured on HS shaft of Vorecon at around 10600 rpm with a constant frequency of around 146 Hz leading to compressor tripping on Verocon high speed pinion vibrations.**
- **Compressor behaviour is normal.**
- **Temperature on shaft line is normal.**

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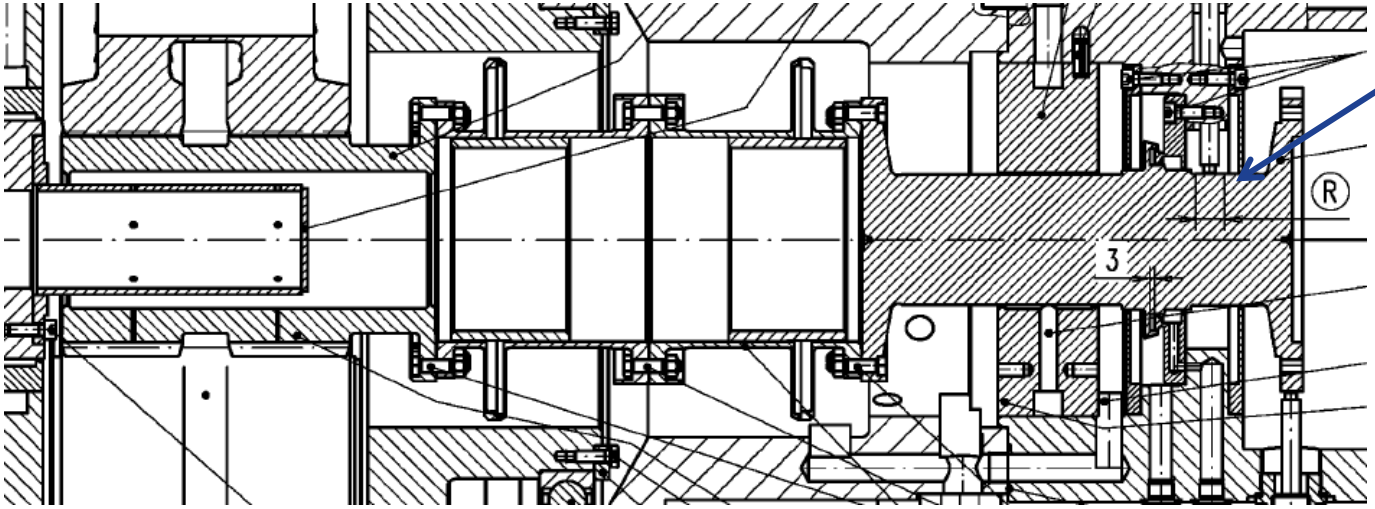
High speed coupling overview



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- **Historical background**
  - **Initial design of Vorecon : 2005**
  - **Voith workshop test : March/April 2005 at 1,5 MW load (Compressor trains 11,12, 21, 22, 31 &32)**
  - **Full load test in GEThermodyne : September/November 2005 on two units**
  - **Issue of subsyncronous vibration was raised regarding the vorecon design of this order and other jobs.**

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- **Historical background (Contd.,)**

RCA indicated two causes :

- **Vibration induced by machining influence on Annuli**
- **Vibration induced by the spline coupling**
- **Modification performed :**
  - **Machining of annuli was already taken into account for initial design.**
  - **Modification of coupling done on site in 2012 by Voith.**

Note: The 2 units for KC041&42 were produced with the upgraded design and tested at Voith workshop test at 1,5 MW (August 2008)

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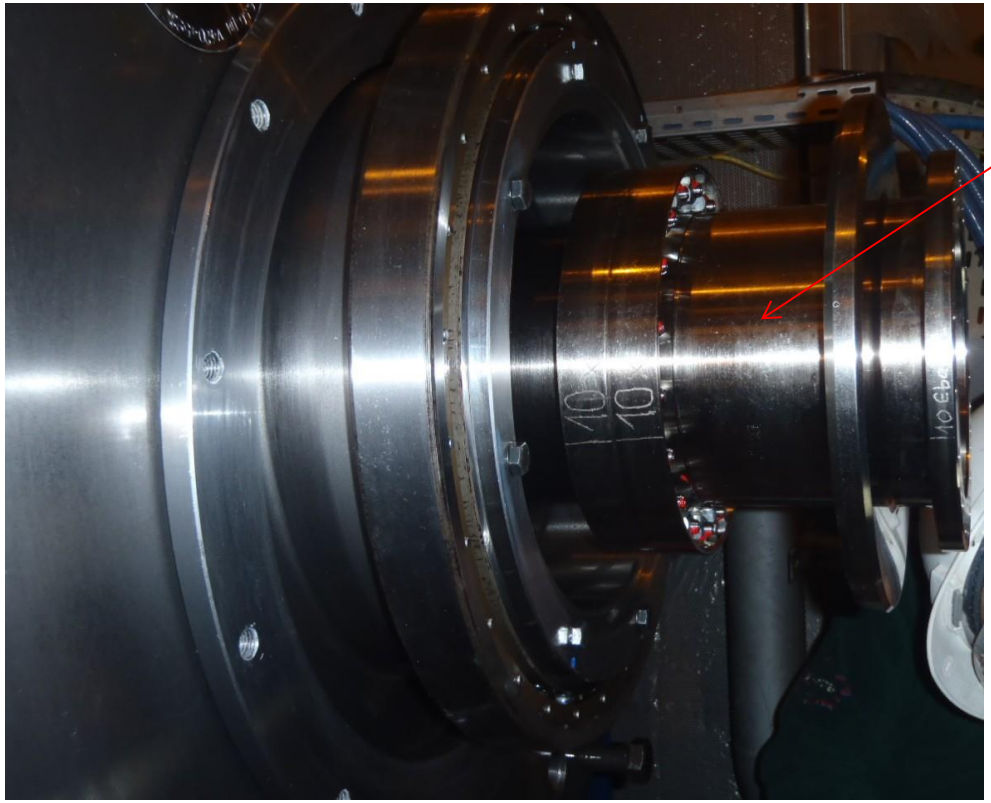
Inspection of unit KC011



Diaphragm coupling

Inspection show balancing marks OK and visual no damage found on the half coupling towards high speed shaft.

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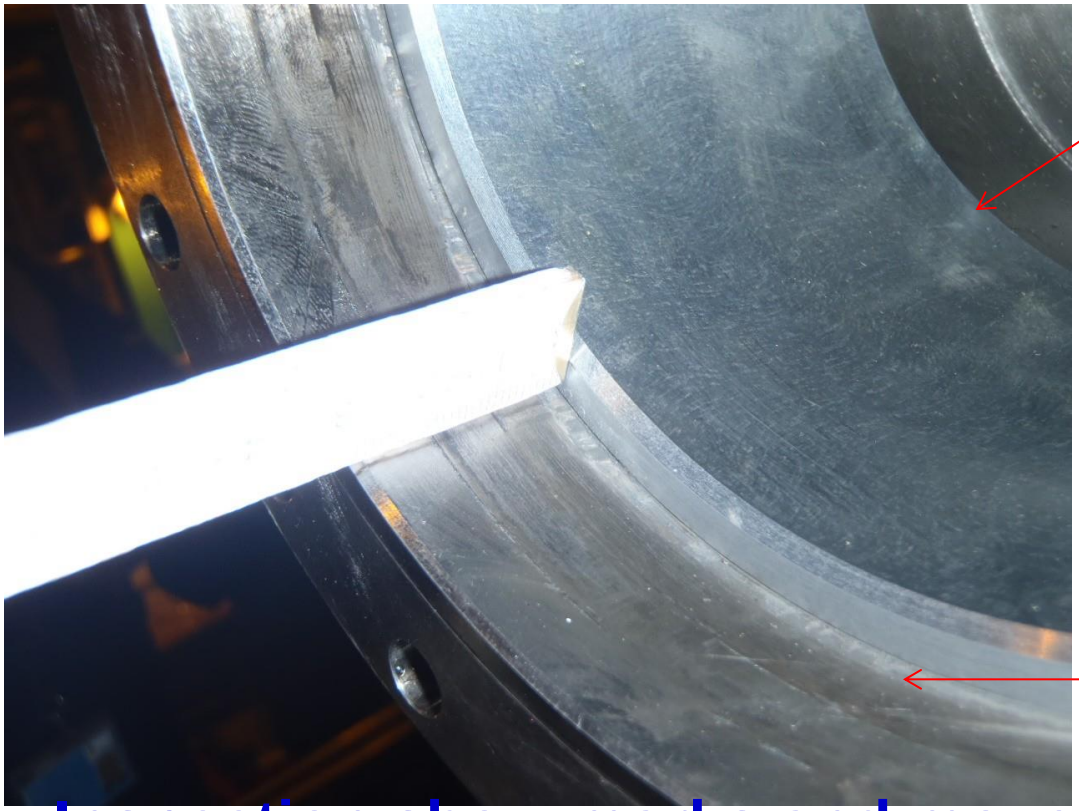
Inspection of unit KC011



Inspection show marks and movement of both catching rings of the diaphragm coupling.

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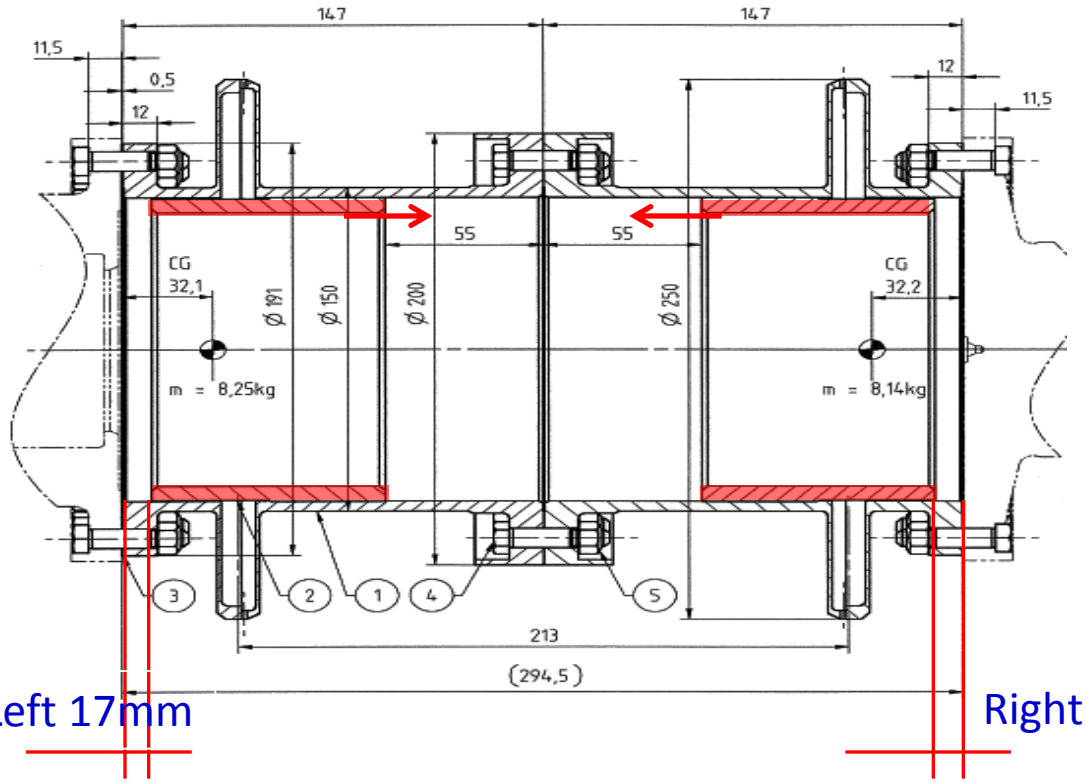
- **Inspection of unit KC011**



Design values:
left side should be ~10mm
right side should be ~12mm

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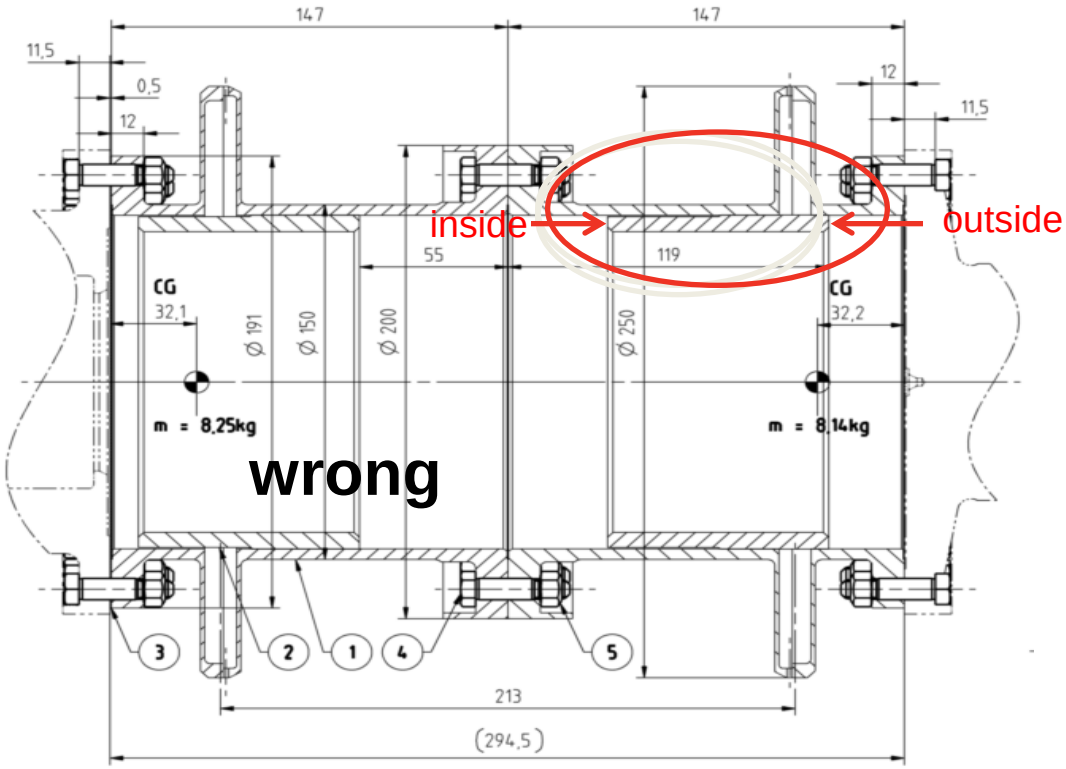
Inspection of unit KC011



Inspection show that both catching rings are assembled in wrong direction and the pressure fit is on the outside.
Check with feeler gauge → no gap outside / inside gap found

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- **Inspection of unit KC011**
  - **The spare runner was already checked and presents the same wrong assembly.**
- **We can suspect that units 12, 21, 22, 31 and 32 are also impacted since all diaphragm couplings have been assembled the same day**

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- **Inspection of unit KC011**

Inspection of the bearing 11 show no damage. The wear on the surface is a link to the increased vibration.

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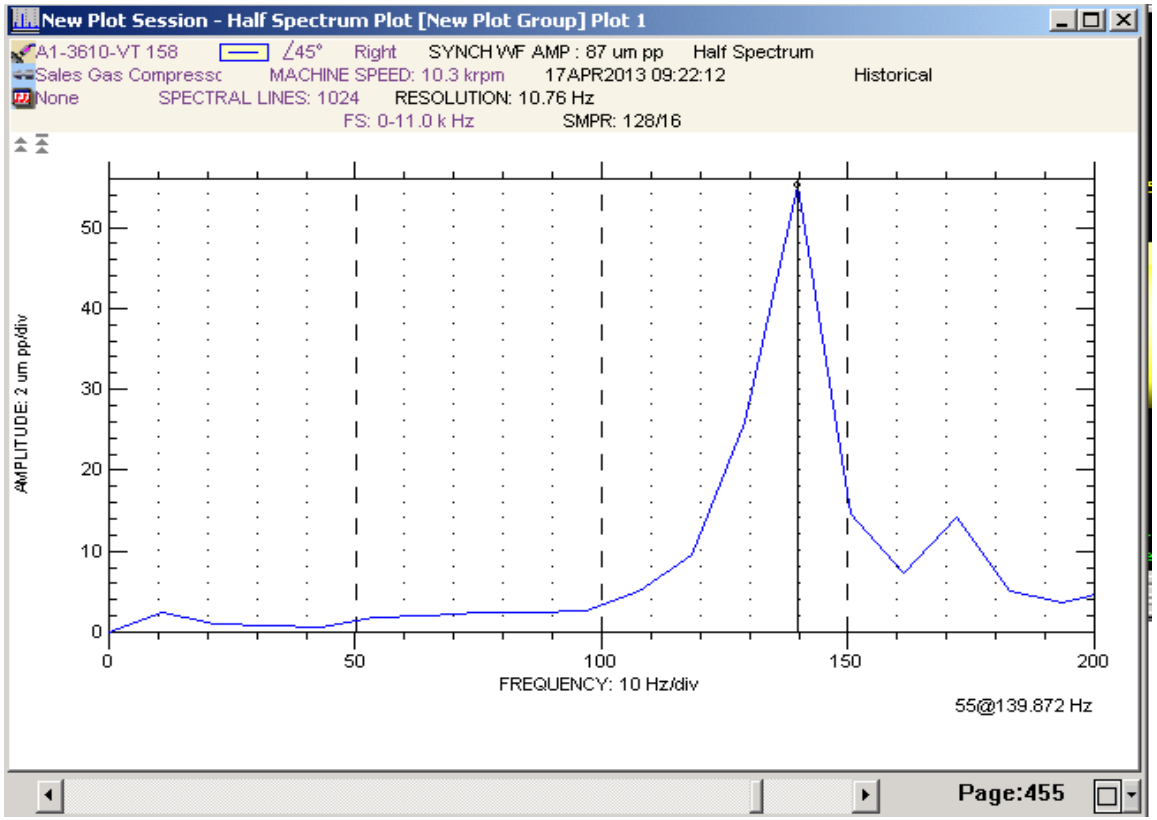
Vibration data analysis from site: KC-11



Spectra show a second dominating mystery peak at 139,87Hz. Rotation frequency is 171,66Hz (10300rpm).

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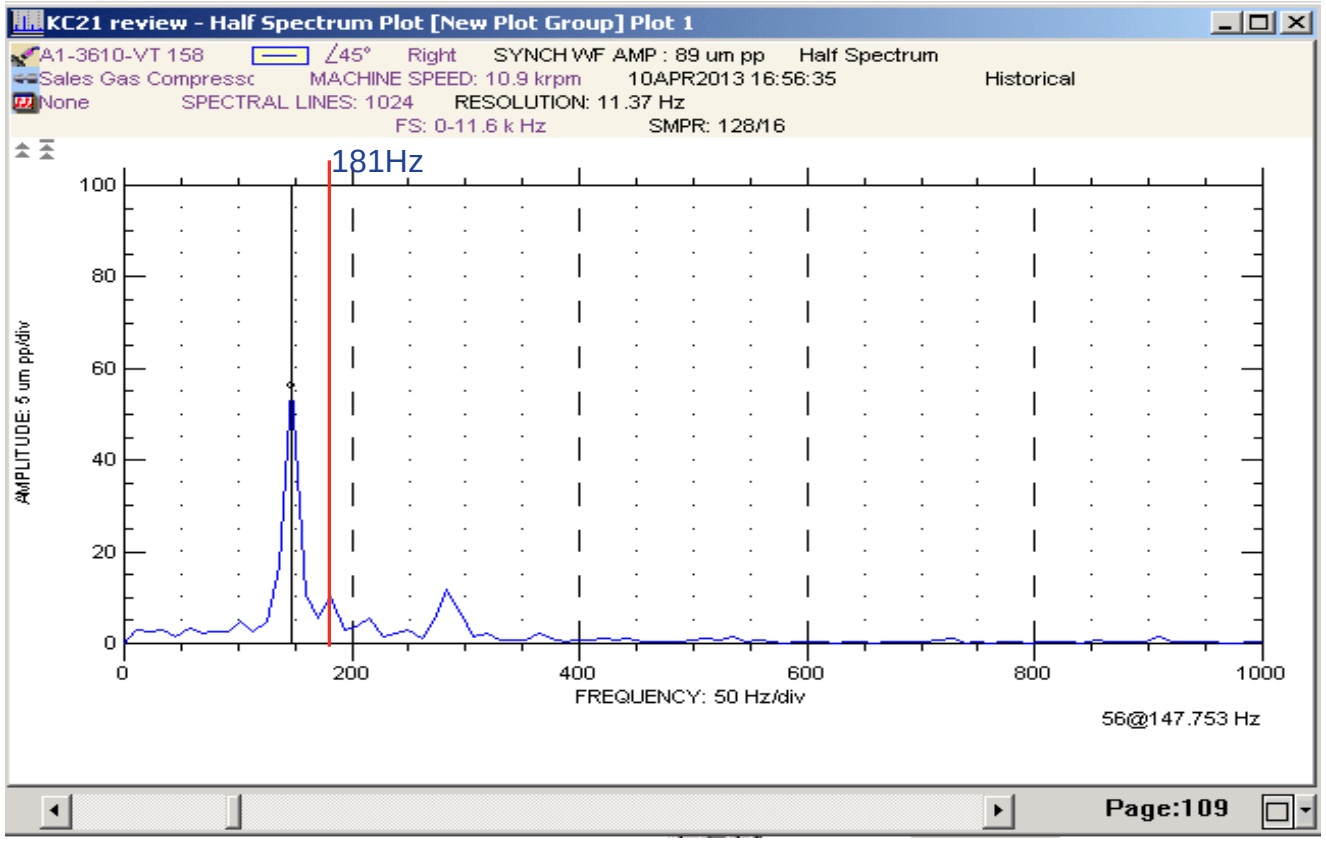
Vibration data analysis from site



Spectra show a second dominating mystery peak at 147,75Hz. Rotation frequency is 181,66Hz (10900rpm).

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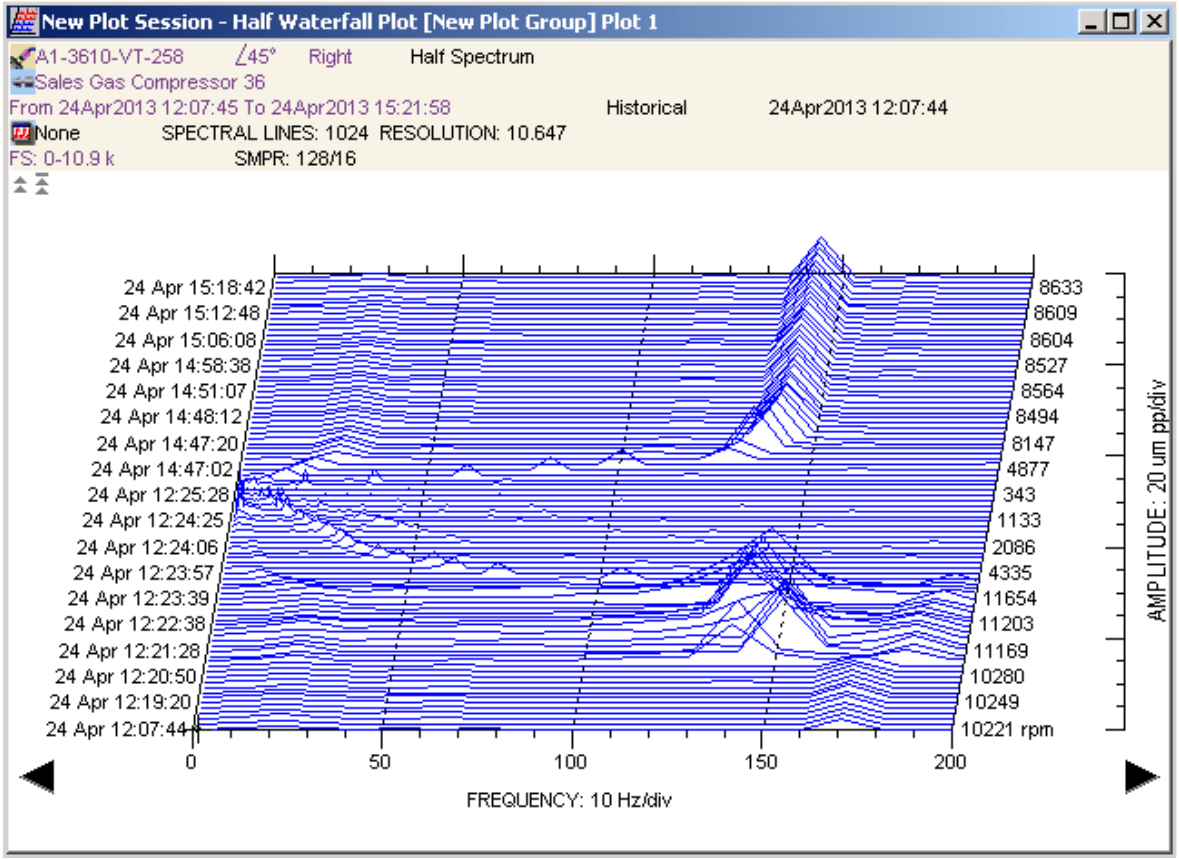
Vibration data analysis from site



Waterfall plot show the peak occur after speed increase and machine trip because of vibration. Restart show increased ground level after restart.

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Coupling design check

Voith performed different checks with its supplier BHS:

- **Interference fit check and design margin**
- **Quality check : geometrical check vs drawing requirements**

Check of design of unit 41/42 (Thermodyn Kashagan S 2) and other referenced Thermodyn units show no differences in dimensions and material at revolving planetary gear, diaphragm coupling between sun and output shaft.

Other references are running since years without any increased output shaft vibrations.

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- **Coupling design check (Continued):**
- **Impact analysis of coupling wrong assembly :**
  - **–Frequency analysis has been performed on the baseline geometrical and the configuration as installed at site on unit KC011. it results a signficant impact on 1 axial frequency of the coupling alone with a frequency raising from 118 Hz to 148 Hz**
  - **–Additional the wrong installed sleeves lead to a blockage of the diaphragm elements. So this could lead to the increased vibration level on the VORECON output side in the range of 146-148 Hz.**

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- Coupling design check (Continued)
- Impact analysis of coupling wrong assembly :
  - –The change of the vibration level of 1x after each trip could be explained by changed balancing by movement of the catching ring.
  - –Finally the sliding/friction of the sleeves with diaphragm element could contribute to the generation of cross coupling terms that tend to destabilize the mode. In certain way, this would produce same effect of gear teeth coupling orginally designed for this unit.

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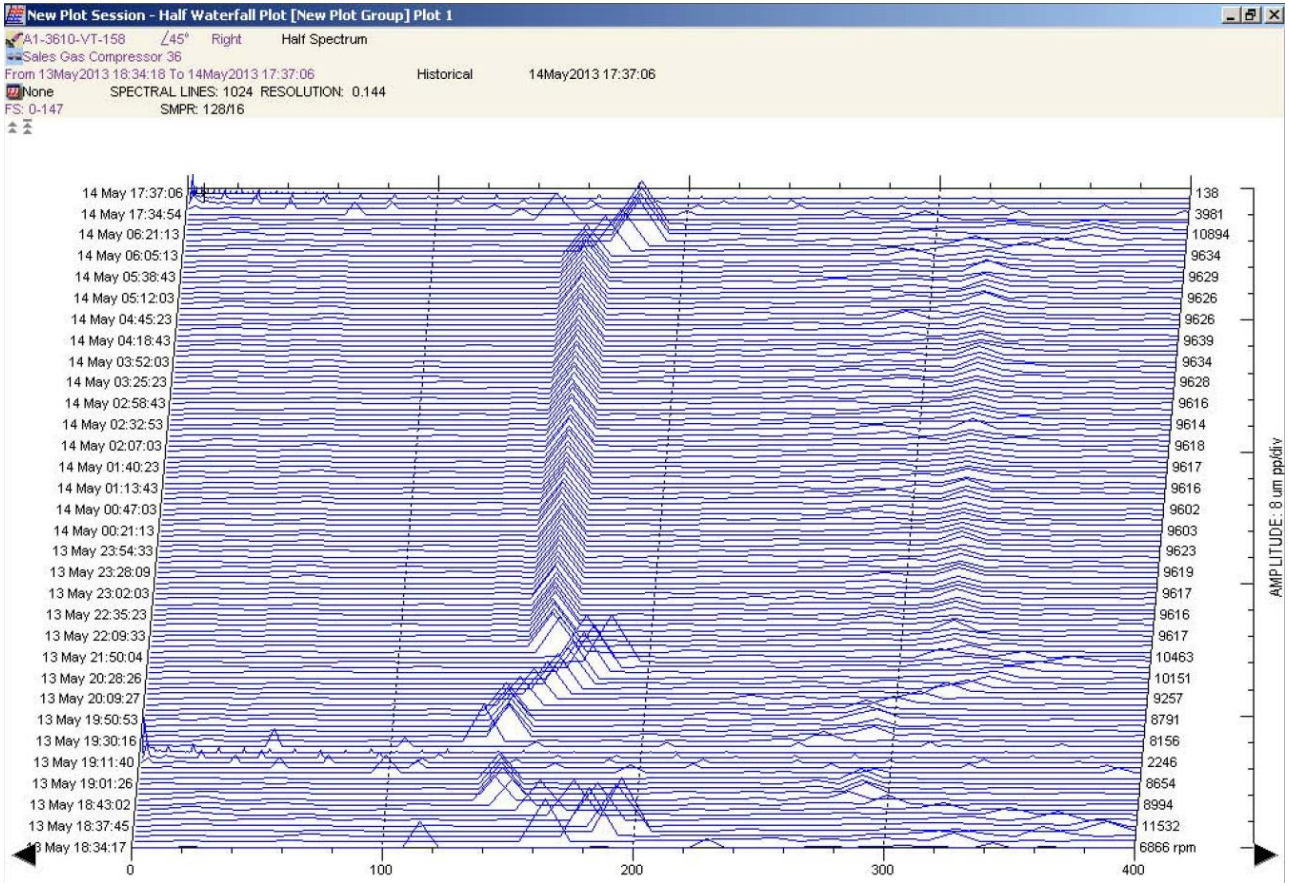
Vibration level output shaft unit 11 after re-commissioning (with parts from train 41 / 42)



Waterfall plot from speed increase up to 11500 rpm and higher did not show a mystery peak. Vibration level is low over the complete speed range.

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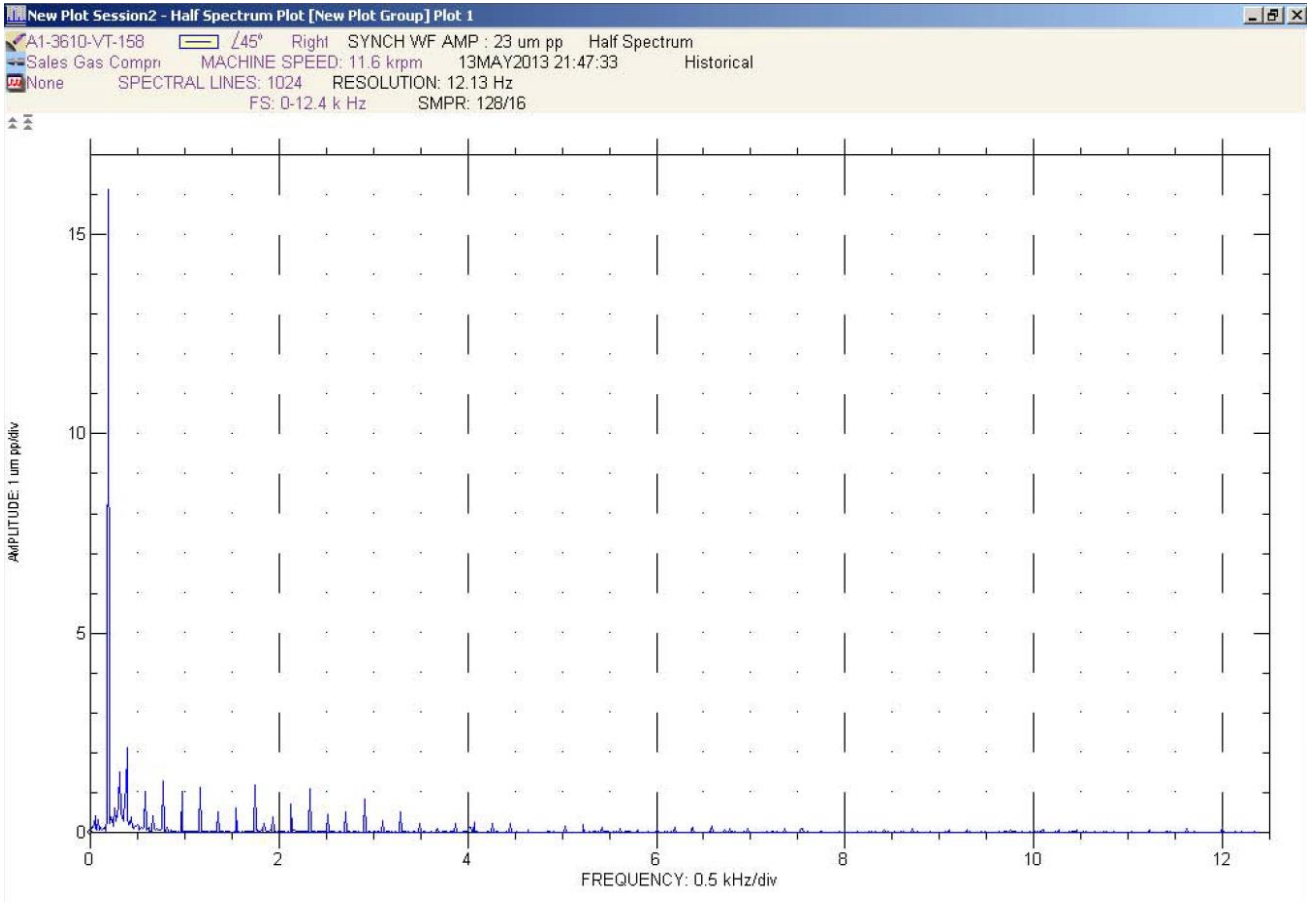
- **Vibration level output shaft unit 11 after re-commissioning (with parts from train 41 / 42)**



Spectrum from output shaft Vorecon at 11600 rpm output speed, show low values and no mystery peak.

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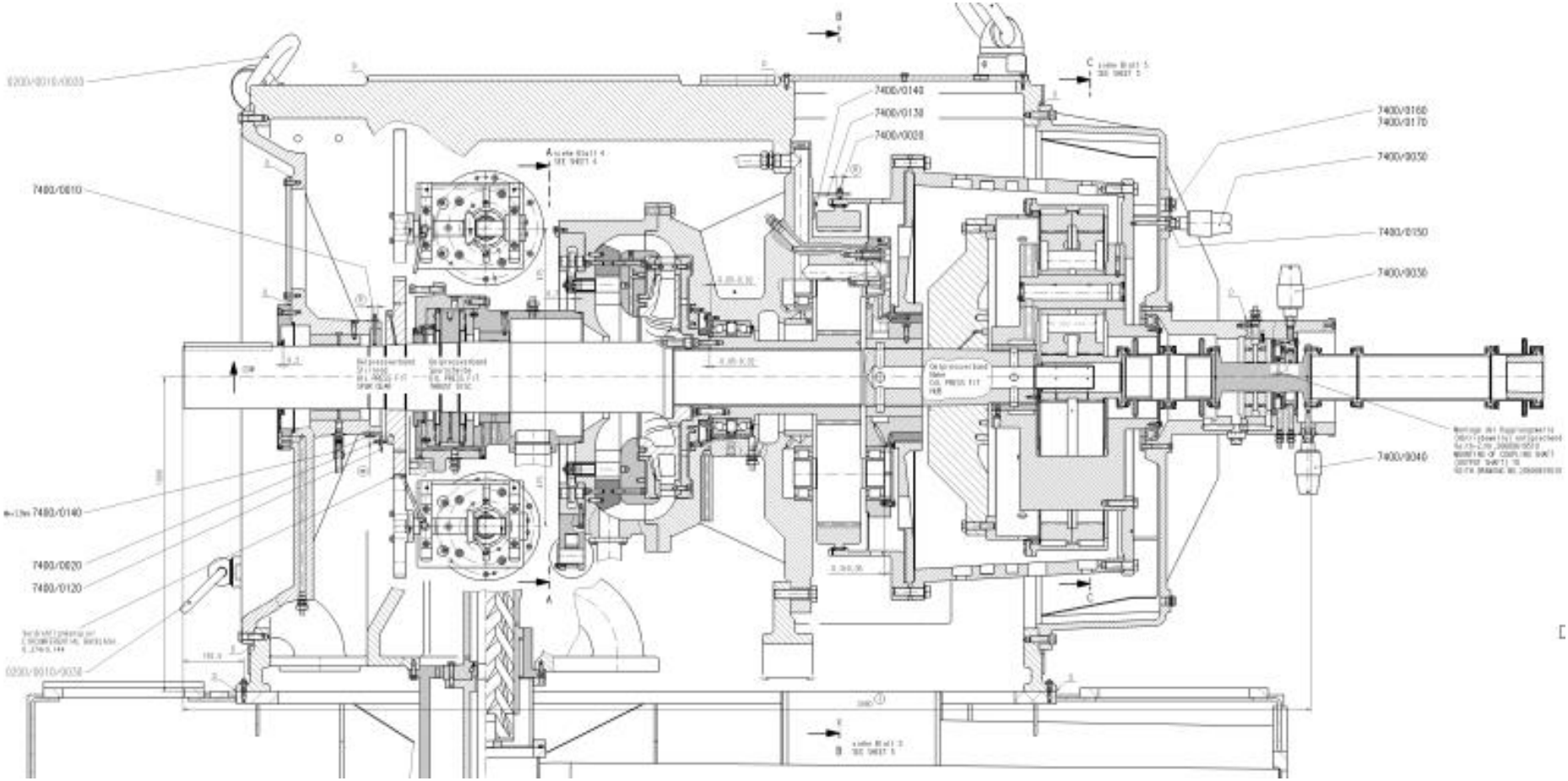
Conclusion

Based on the findings on the dis-assembled inner diaphragm as well as the operating behavior of the VORECON after installation of the rev. planetary gear of train 41/42 the wrong assembly of the inner diaphragm coupling has caused the increased vibration level on the VORECON output side. After installation of correct assembled inner diaphragms the vibration level is as expected.

Root cause for the increased vibration level during first commissioning activities was the wrong assembled inner diaphragm coupling!

Cross Section



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- Slide 2: Presenter/Author bios

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